Noteworthy anatomical and physiological researches.

The periodic reduction of chromosomes in living organisms.

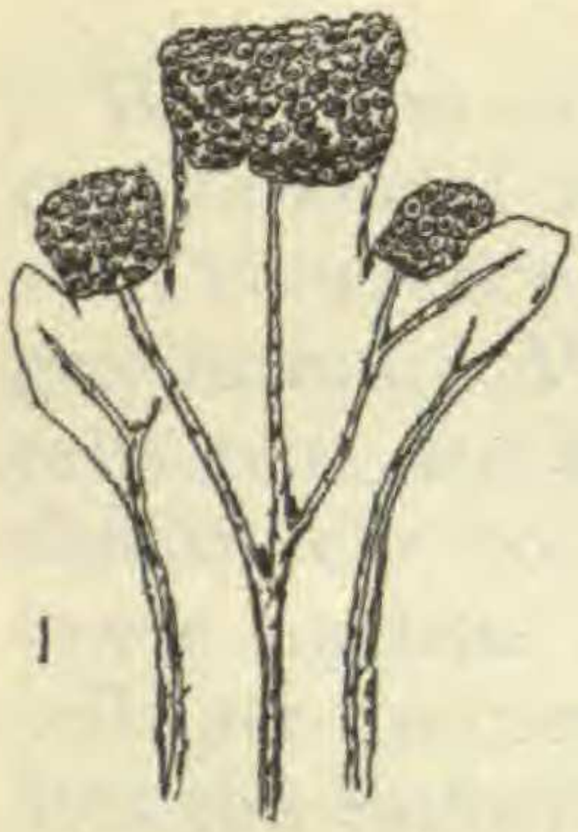
Under this title Professor Eduard Strasburger communicated a very important paper to section D of the British Association last August. A translation of the paper appears in the *Annals of Botany* for September, and so many of our previous views are affected by it that it deserves a somewhat full mention.

Calling attention in the outset to the fact that sexual differentiation in plants was preceded by asexuality, the author shows that when this differentiation was attained it finally led to the production of a new generation set apart to spore production, and that in alternation of generations the sporophyte is the newer generation, having arisen from the gametophyte. In the production of this sporophyte it has been noted that the two gametes concerned have nuclei containing half the number of chromosomes characteristic of the nuclei of the resulting sporophyte, and this reduction has been regarded as a special preparation for the sexual act. Upon this hypothesis there have been constructed various theories with regard to the reduction and to the significance of the sexual act. Strasburger and other observers find, however, that this reduction in the number of chromosomes in the generative nuclei of angiosperms is determined in the mother-cells of the pollen and embryo-sac, and not during the maturation of the sexual cells. The physiological utility of this reduction is evident in the prevention of the indefinite increase of chromosomes with every succeeding generation and in securing the equal representation of each parent. The morphological cause, however, is phylogenetic, for it is simply a return to the original generation which had attained sexual differentiation, and which in consequence had developed as offspring sporophytes containing nuclei with double the number of chromosomes. This reduction, therefore, is not the outcome of a gradually evolved process of reduction, but is the sudden reappearance of the primitive number of chromosomes as it existed in the nuclei of the generation in which sexual differ-

entiation first took place. This reduced number which is determined in the spore mother-cells in angiosperms persists in all subsequent divisions to the formation of the generative nuclei, involving usually four divisions in the history of the male nucleus, and five in the case of the female, although in the latter case the divisions may be three, four, five or more. It is evident that the attempt to establish homologies between the successive divisions preceding the formation of the two generative nuclei is futile; and it is equally worthless to claim on physiological grounds the necessity for a certain definite number of nuclear divisions that the two nuclei may be brought to the same bulk. The reduction in the number of chromosomes, therefore, is not to be regarded as a preparation for the sexual act, but it marks the beginning of a new generation which comes into existence with the primitive number of chromosomes, of which generation the spore mother-cell is the initial cell.

Professor Strasburger traces backwards the phylogenetic course of the reduced ontogeny exhibited by the primitive sex-differentiating generation in angiosperms. In the developing endosperm of gymnosperms the reduced number of chromosomes is found long before the development of archegonia has begun.

This further emphasizes the fact that the number of successive nuclear divisions which precede the generative nucleus is very variable and holds no relation in the parallel male and female generations. In pteridophytes and bryophytes the number of chromosomes is hard to determine on account of the small nuclei of the latter and the great number of chromosomes of the former. In some ferns, however, as Osmunda regalis, the number of chromosomes is as small as in phanerogams, and in this case the reduction appearing in the nucleus of the spore mother-cell persists throughout the prothallium, and is half the number found in the sporophyte. Among bryophytes the counting of chromosomes has been accomplished in a liverwort, which showed four chromosomes in gametophyte nuclei and eight in sporophyte nuclei, the number four appearing first in the spore mother-cell. No countings of the chromosomes in algæ and fungi have been made, due partly to the difficulty of the operation and partly to the lack of appreciation of its importance. That the number of chromosomes in these lower cryptogams is definite Strasburger believes from the few preparations he has examined.



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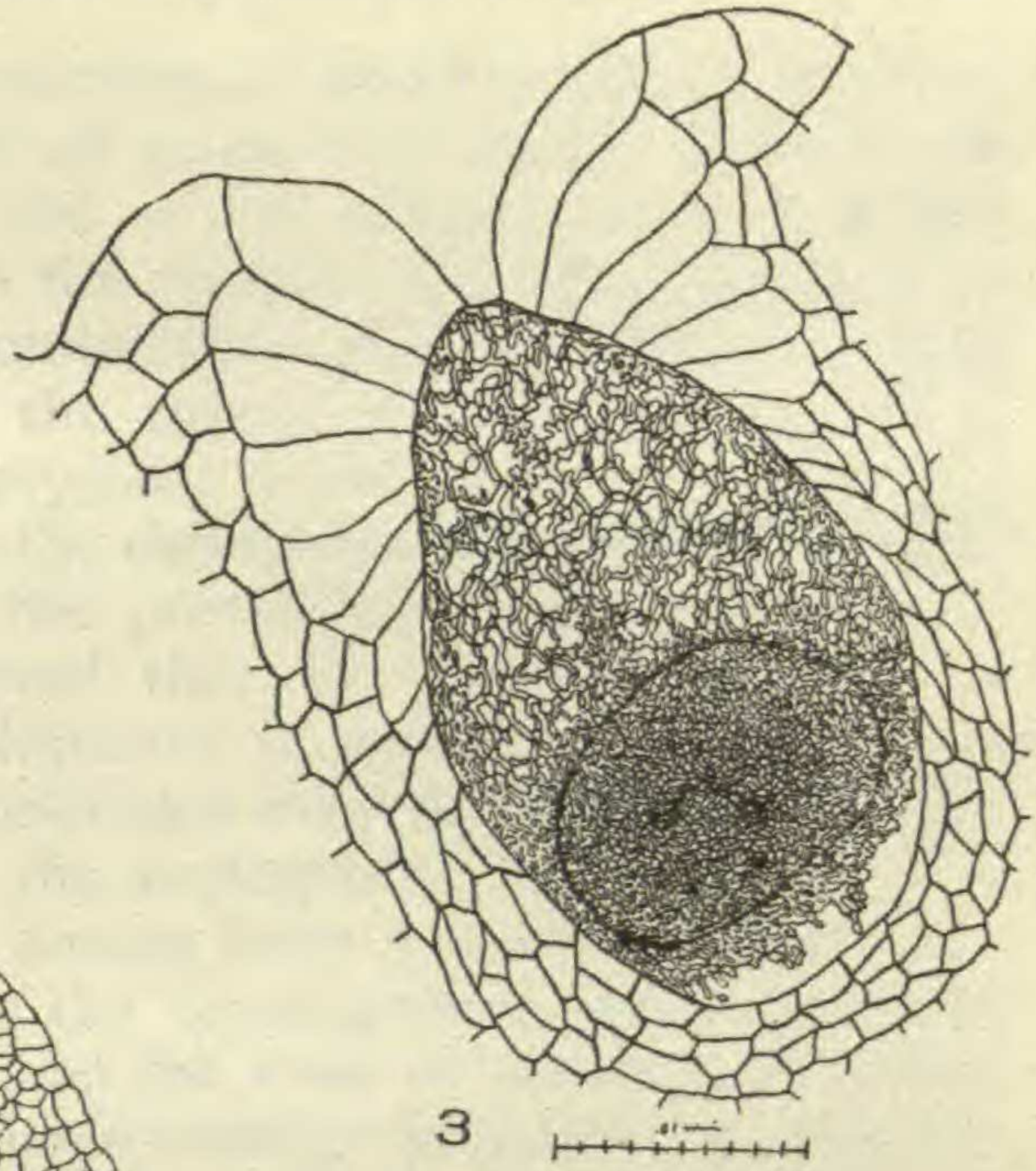

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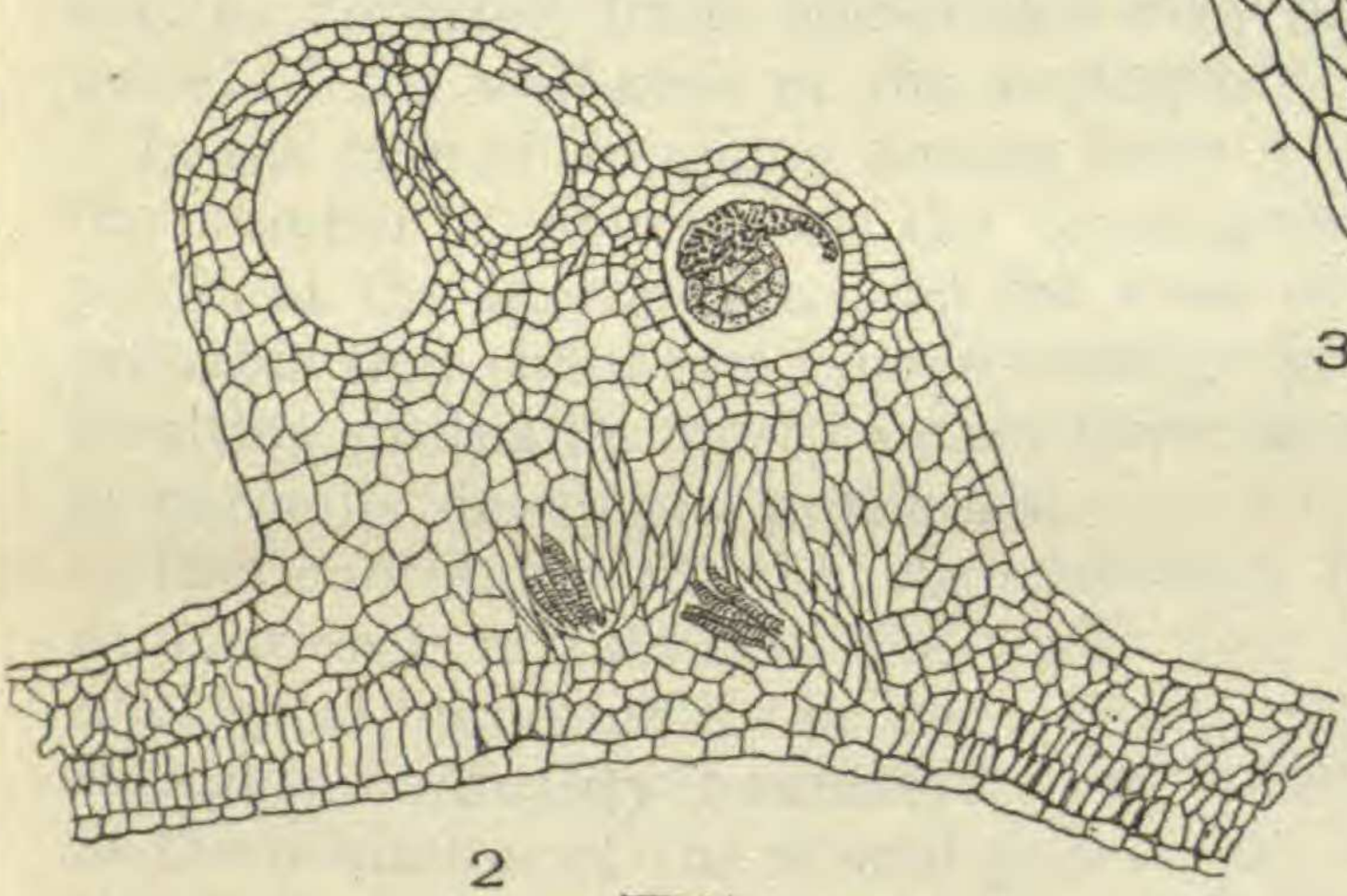

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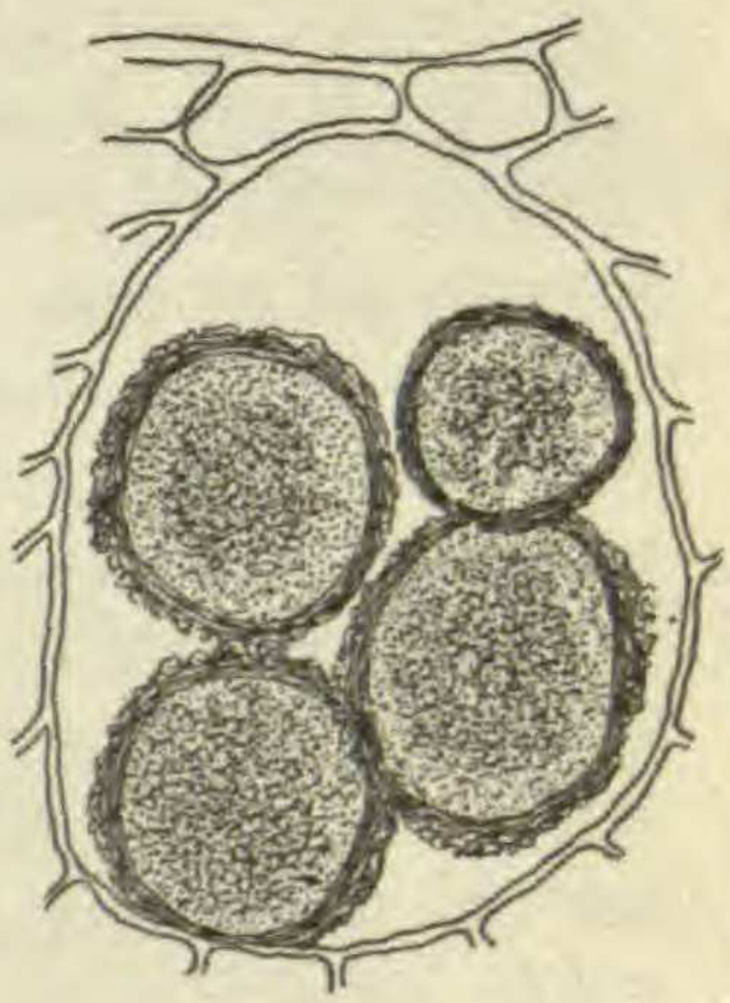

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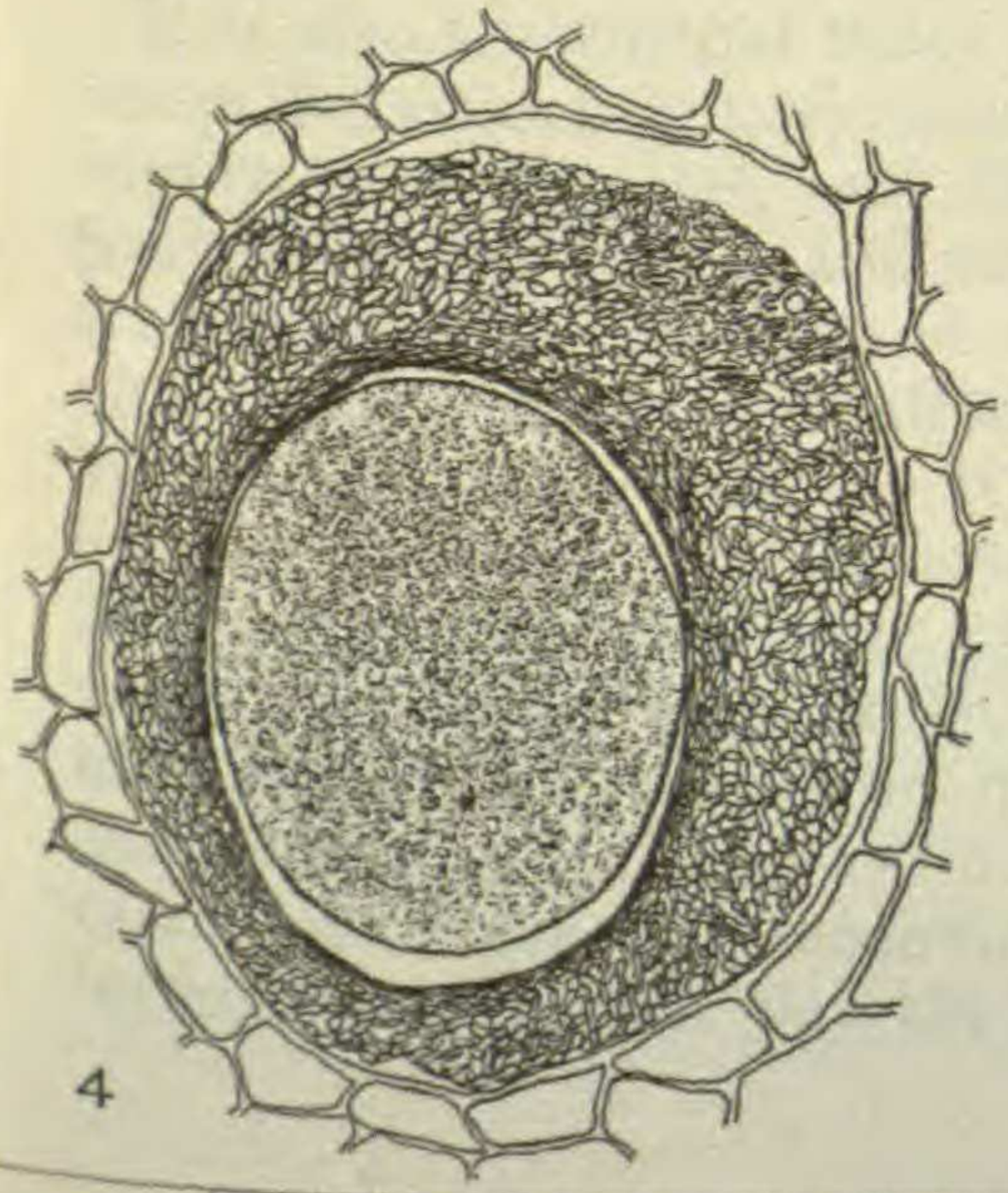

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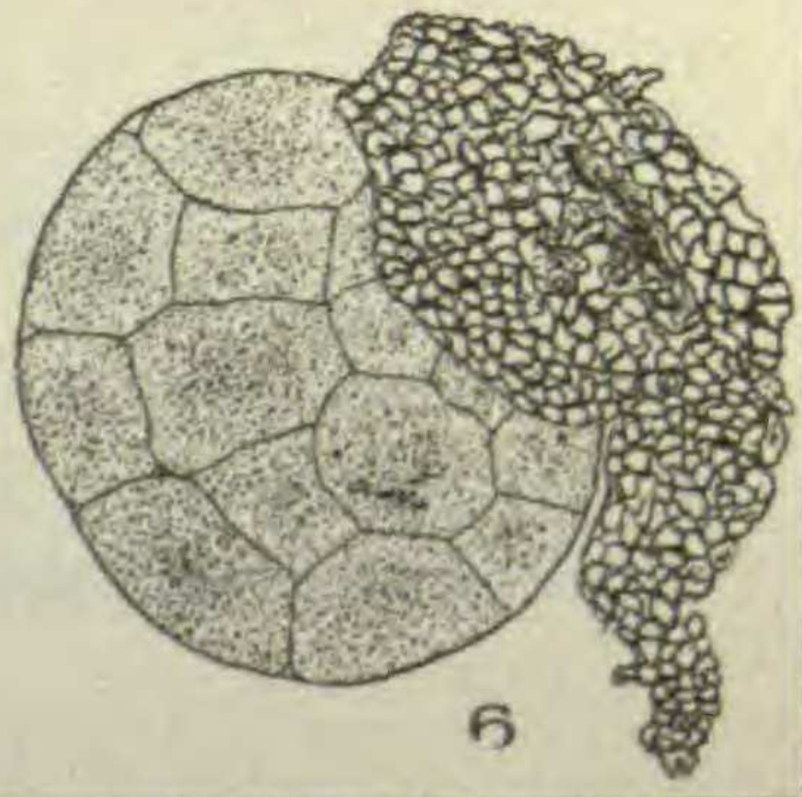

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CLENDENIN on SYNCHYTRIUM.

While constancy in the number of chromosomes in the generative nuclei is doubtless of great importance, there is no such constancy in the nuclei of the somatic cells in either generation. Variations in the number are often observed in cells that are no longer embryonic, and especially in those definitively excluded from the sphere of reproduction (as the lower nucleus of the embryo-sac from which the antipodal cells are derived, and also the definitive nucleus which originates the endosperm). In the prothallial nuclei of Pinus sylvestris it has been observed that the reduced number is adhered to until the development of archegonia, and then it may be departed from, sometimes even doubling in the large nuclei of the wall-cells of the archegonia.

In the case of apogamy among ferns it seems probable that the number is doubled on the development of the growing points of the sporophyte. In the case of apospory it seems probable that there is a corresponding reduction, or else the resulting prothallia must contain twice as many chromosomes as normally developed prothallia.

The continuity of the chromosomes from generation to generation is maintained, and while they may lose their morphological individuality in the resting nucleus, their physiological individuality is retained. The reduction in the number at the initiation of the sexual generation is said to be due to the fusion of two chromosomatic individuals into one, and this is preceded by the ordinary nuclear division. There is no such thing among plants as nuclear divisions resulting in the reduction of the number of chromosomes by one-half.

It is also shown that there is no such thing as hereditarily unequal divisions in karyokinesis. The author believes thoroughly in epigenesis, and that cell-nuclei, wherever in the body they may be, are and remain endowed with all the characteristics of the species and are stimulated to activity in definite directions by prevalent conditions. He approves of Weismann's term "id," as it represents something supported by direct observation. He would recognize as ids the serially arranged discoid segments of the chromosomes. These ids are repetitions of each other, and in the sexual act the chromosomes of the parents do not lose their independence, but show various results in various parts dependent upon the interaction of the chromosomes giving rise to phenomena of interference. In this way the various resemblances of hybrids